Adsorption of Iodide by Soils in the Presence of Some Inorganic Substances

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Soil is a heterogenous system containing a complex mixture of organic substances which may be in different colloidal and amorphous forms in nature [4]. Soil colloids are never found to consist either of inorganic or organic substances only. Crystalline soil colloids containing organic substances play a great role in such phenomena as adsorption and exchange of ions. The crystalline colloids expose to their surfaces different degrees of positive and negative charges depending on their internal saturation at different lattices by different measure of cations. This difference, in the internal lattice arrangement, leads to different surfaces with different degrees of positive and negative charges. There will, obviously be difference in the nature and amounts of ions adsorbed or exchanged and consequently the form of surface lattice is unpredictable.

In our previous communication [3], we emphasized the difficulty of isolating the factors responsible for the type of iodide adsorption observed or the different amounts of negative adsorption by different types of soils. This we said to be reasonable as we cannot expect from such a complex system a well defined behaviour that we commonly observed with a single or more than one type of mixture of pure substances.

In the present paper it was, therefore, deemed necessary to apply some treatments for determining the effects of some inorganic substances on the adsorption of iodide by soils. This, we hoped, might give some indications of the inorganic substances or ions which help positive iodide adsorption by these natural systems.

Experimental

The effects of the following factors on iodide adsorption were studied

(a) Free iron oxide
(b) Sesquioxide
(c) Calcium carbonate and exchangeable calcium and magnesium
(d) Calcium, ammonium, hydrogen and potassium ions.

For observing the effects of free iron-oxide, the soils were treated as described by DE [2]. Sesquioxide fraction of the soil was complexed by treating 20 g of each soil with 5% 8-hydroxyquinoline at pH 4.3 for 24 hours. Excess of the reagent was removed by treating repeatedly the experimental soil sample with 60% alcohol. The soil was dried after making it free of reagent at 80°C in an electric oven for 8 hours.

For observing the effects of calcium carbonate and exchangeable calcium and magnesium, 20 g of each soil sample were treated with 100 ml of 5% aqueous solution of sodium salt of E.D.T.A. The mixture was kept for 24 hours and after the lapse of the period was washed with 60% alcohol to make the soil free of the excess reagent. After filtration the residue was dried at 80°C for 8 hours and then preserved for the experiment. The effects of calcium, ammonium, hydrogen and potassium ions were observed by converting each soil sample into calcium, ammonium, hydrogen and potassium soils. For the preparation of the derivatives, 20 g of each soil sample were treated with 100 ml aqueous solution of the respective chloride salts. The mixture was first thoroughly and then periodically shaken and kept for 24 hours to attain equilibrium. After the lapse of the period, the treated soil was washed with double distilled water and then with 60% alcohol. The treated soil was then dried in an electric oven at 105°C for 10 hours and used for the experiments. The details of the soil used have already been given [3]. The results of adsorption reported are in terms of 5 g soil per 100 ml iodide solution. The texture of the soil samples was determined by the International pipette method [1].

The iodide was determined titrimetrically [5] using diiodo-fluorescein as an adsorption indicator (1 ml N/10 $AgNO_3$ = 0,01269 g of Iodide).

Results and discussion

A perusal of tables (1—3) will clearly show that free iron-oxide, soil sesquioxide, calcium carbonate, exchangeable calcium and magnesium and ions like calcium, ammonium, hydrogen and potassium influence appreciably iodide adsorption by soils. These factors have been found either to increase negative adsorption or to shift the adsorption towards the positive side (Tables 2 and 3).

The probable explanations for the role of the different factors in iodide adsorption by soils are given in the following:

a) *Free iron oxide*

As has already been emphasized in the introductory part of this paper, the crystalline colloids are saturated internally by different numbers of positive ions leading to differently charged negative surface. In the natural state, such a surface is always coated with organic and inorganic substances including free iron-oxide. The exposure of the negative surface of the soil colloid will, therefore, depend on the ratio between the organic plus inorganic substances and free iron oxide. It is quite obvious that as the free iron oxide is removed the negative surface is exposed to different degrees in different types of soils and, therefore, either increase or decrease in negative adsorption may be observed in the treated soil samples in comparison to the untreated ones. Thus, on treatment negative adsorption still increased in soil A (Alluvial soil, sandy loam), D (Laterite soil, loamy sand), I (Black cotton soil, clay) and J (Red soil, sandy loam). The negative adsorption shifted towards the positive side in the case of soils F (Hilly soil, loam), G (Alluvial soil, sandy clay loam) and H (Red soil, clay loam). Free iron oxide present in soil is generally in forms which may keep an excess of either positive or negative charges

on its surface. The formation of these two types will depend on the natural conditions under which the different soils are formed. It appears that the free iron oxide is mostly negative in nature especially in the case of soils F, G and H, which are on an average either loamy or clayey loam. Thus, their removal from these soils resulted in positive adsorption.

b) *Sesquioxide*

A similar explanation as given for free iron oxide may be put forward also for this factor. It appears that sesquioxides which exposed negative charges in the natural soil samples were changed in their nature due to a treatment 8-hydroxy quinoline. The negativity of the sesquioxide surface

Table 1

The soil samples and their texture

Soil No.	Type	Source	Texture
A	Alluvial soil	Kerala	Sandy loam
B	Alluvial soil	West Bengal	Silty clay loam
C	Red soil	Bihar	Loamy sand
D	Laterite soil	Orissa	Loamy sand
E	Alluvial soil	Sikkim	Silty clay loam
F	Hilly soil	Nepal	Loam
G	Alluvial soil	Uttar Pradesh	Sandy clay loam
H	Red soil	Madhya Pradesh	Clay loam
I	Black cotton soil	Andhra Pradesh	Clay
J	Red soil	Uttar Pradesh	Sandy loam

accounting for a high proportion of the soil surface must have been reduced by an intimate surface connection with oxine. This behaviour will obviously be different for different types of soils and there will be a shift of the negative adsorption towards the positive side. Positive adsorption was recorded by soil B. (Alluvial soil, silty clay loam), C (Red soil, loamy sand), D (Laterite soil, loamy sand), F (Hilly soil, sandy loam), H (Red soil, clay loam), J (Red soil, sandy loam). In these cases i.e. with soils which are generally loamy sand or sandy loam, it may be said that the negativity of the sesquioxide surface was less and was, therefore, easily reduced in its effect on iodide adsorption and resulted in positive adsorption.

c) *Calcium carbonate and exchangeable calcium and magnesium*

For these factors, it may be said that the negativity of the soil surface was reduced due to reactions or coating at these places with the compound, ethylenediamine tetra-acetic acid. This reduction will be obviously different for different types of soils and there will be difference in the degree of shifting from the negative towards the positive adsorption. Thus, soils C (Red soil, loamy sand) and D (Laterite soil, loamy sand) recorded positive adsorption. It may, therefore, be said that the surface of these soils which are generally loamy sand were suitable for positive adsorption due to the effect of this treatment.

Table 2

Effect of free iron oxide, sesquioxide and calcium carbonate and exchangeable calcium and magnesium on iodide adsorption by soils

Soil Type	Adsorption (mg/100 ml of solution)			
	Free iron oxide	Sesquioxide	Calcium carbonate and exchangeable Ca & Mg	Natural soil
A	—3,04	0,00	0,00	—1,52
B	0,00	+0,51	0,51	—1,77
C	—0,51	+1,01	+0,51	—0,76
D	—2,54	+0,51	+0,51	—0,76
E	0,00	0,00	—0,51	0,00
F	+0,51	+0,51	0,00	—1,01
G	+0,51	—0,51	0,00	—0,76
H	+0,51	+0,51	0,00	—1,27
I	—3,04	0.00	0,00	—1,01
J	—3,04	+0,51	0,00	—0,51

d) *Effects of calcium, ammonium, hydrogen and potassium ions*

We have so far stressed that the positive adsorption of iodide by soils can be achieved provided the factors which increase the negativity of the soil surface are removed. This explanation appears to be reasonable specially when the observations recorded in table 3 are analysed. The saturation of the soils with any of these four ions obviously decreased considerably the negative spots on the soil surface. It appears that soils saturated with ammonium or

Table 3

Adsorption of iodide by calcium, ammonium, potassium and hydrogen soils

Soil Type	Adsorption (mg/100 ml of solution)				
	Calcium soil	Ammonium soil	Potassium soil	Hydrogen soil	Natural soil
A	+0,51	+0,51	+1,01	+0,51	—0,51
B	+0,51	0,00	0,00	0,51	1,77
C	+0,51	0,00	—0,51	+0,51	—0,76
D	0,00	+0,51	—1,01	—0,51	—0,76
E	—0,51	0,00	0,00	0,00	0,00
F	0,00	+0,51	0,51	—0,51	—1,01
G	+0,51	0,00	0,00	0,00	—0,76
H	0,00	+0,51	—0,51	—0,51	—1,27
I	0,00	0,00	0,00	+0,51	—1,01
J	0,00	+0,51	+0,51	0.00	—0,51

hydrogen ions and in some cases with calcium or potassium ions exhibit a tendency to retain iodide on their surface. This, however, varied in proportion and also in nature according to soil type. Thus, especially in the calcium derivatives of soils A (Alluvial soil, sandy loam), B (Alluvial soil, silty clay loam), C (Red soil, loamy sand), G (Alluvial soil, sandy clay loam), the positive

adsorption is more prominent than in the calcium derivatives of other soils. Positive adsorption was recorded by the ammonium derivatives of soils A (Alluvial soil, sandy loam), D (Laterite soil, loamy sand), F (Hilly soil, loam), H (Red soil, clay loam) and J (Red soil, sandy loam). Similar adsorption was also recorded by the potassium derivatives of soils A (Alluvial soil, sandy loam), F (Hilly soil, loam), J (Red soil, sandy loam) and in the hydrogen derivatives of soils A (Alluvial soil, sandy loam), B (Alluvial soil, silty clay loam), C (Red soil, loamy sand) and I (Black cotton soil, clay). The degree of this shift towards positive adsorption or negative adsorption as observed in the calcium derivatives of soil E (Alluvial soil, silty clay loam) and the potassium derivative of soil D (Laterite soil, loamy sand) depends not only on the soil type but also on the nature of the cation with which the soil is saturated.

From the foregoing observations, it is quite clear that positive adsorption of iodide on soils can be achieved if for a particular soil a particular factor is removed or complexed or the soil is saturated with a particular type of cation.

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Summary

The effects of free iron oxide, sesquioxide, calcium carbonate, exchangeable calcium and magnesium, calcium, potassium, hydrogen and ammonium ions have been observed on iodide adsorption by ten typical soil samples. Positive adsorption of iodide on soils can be achieved if for a particular soil a particular factor is removed or complexed or the soil is saturated with a particular type of cation.

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